Operative Techniques in Thoracic and Cardiovascular Surgery

Video-Assisted Thoracoscopic Bilobectomy

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With the evolution of minimally invasive surgery, more complicated surgeries have to be redefined from a technical standpoint in order to facilitate efficient as well as safe dissection. Bilobectomy is a rare operation – however, one must be skilled at performing it via a thoracoscopic approach as we recognize that minimally invasive surgery is more cost effective and associated with lower morbidity and mortality. In this paper, we highlight some of the technical considerations that will allow surgeons to perform a safe and expeditious resection of two lobes simultaneously.
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KEYWORDS VATS, bilobectomy, upper and middle lobectomy, middle and lower lobectomy

Definition

Bilobectomy is the surgical resection of 2 contiguous lobes of the right lung, either the upper and middle lobes or the middle and lower lobes. Although the lobes can be resected separately, certain steps can be taken to expedite the dissection and make the resection of both lobes faster. The focus of this article is to describe the indications and technique employed for thoracoscopic bilobectomy.

Indications

Occasionally, tumors are located such that they require simultaneous resection of 2 contiguous lobes on the right to achieve complete resection. There are a few indications when a bilobectomy should be considered:[1,2]

(1) When a tumor involves the fissure such that R0 resection would require resection of both lobes (ie, when a wedge or segment resection is not possible for the nondominant lesion).
(2) T4 disease, when 2 distinct tumor nodules are located in 2 separate lobes and there is no N3-category disease or persistent N2-category disease after neoadjuvant treatment (stage IIIA).
(3) Central tumors located in the right lower lobe or right middle lobe bronchus such that a negative bronchial margin would require resection of both middle and lower lobes and a sleeve resection is not an option.

Contraindications

There are a few contraindications when a bilobectomy should either not be offered or aborted:

(1) If a tumor is located in the proximal bronchus intermedius or hilum, such that a bilobectomy would not yield a negative margin, a pneumonectomy should be considered (as long as the patient has adequate pulmonary function tests to tolerate a pneumonectomy).
(2) Patients with marginal lung function should be offered an attempt at a sleeve resection or be treated with other modalities such as stereotactic body radiation therapy, radiofrequency, or microwave ablation.
(3) Other more common contraindications that apply to all patients with lung cancer including contralateral or metastatic disease and persistent N2-category disease after neoadjuvant treatment.

Preoperative Preparations

A surgeon can optimize the perioperative course by encouraging the patient to quit smoking, exercise preoperatively, supplement their nutrition, and enroll in aggressive pulmonary rehabilitation, particularly for high-risk patients.

After evaluation of the tumor and airways on bronchoscopy, the next step is to stage the mediastinum (N1-3–category disease, Fig. 1A). Flexible bronchoscopy is used to

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determine any endobronchial component of the tumor, and it is often at this point where airway is assessed to determine if a patient will require resection of one lobe or two to achieve R0 resection. The mediastinum is assessed via either endobronchial ultrasound (Fig. 1B) or mediastinoscopy (Fig. 1C). Patients with N1-category disease (parenchymal and hilar lymphadenopathy) are considered resectable, while typically, patients with macroscopic N2-category disease or contralateral N3-category disease should be treated with upfront chemotherapy or chemoradiation (Fig. 1A). After ensuring limited disease or adequate response to neoadjuvant therapy, surgical resection is considered.

Technique

Patient Positioning

A double-lumen endotracheal tube is placed. The patient is then positioned in left lateral decubitus with the right side of the chest facing up. An axillary roll is placed and the operating table is flexed. Position of the double-lumen tube is re-evaluated and the right lung is then isolated (Fig. 2). Trocar incisions are made next for thoracoscopic resection. Typically, a 1.5-cm camera port is made as the first and foremost incision in the seventh intercostal space for an upper bilobectomy and the eighth intercostal space for a lower bilobectomy at the anterior axillary line (Fig. 3). A 10-mm, 30° camera scope is placed within the pleural cavity and evidence of any pleural metastasis, involvement of the chest wall, and ability to completely resect the tumor is evaluated next. Under direct visualization, 2 (or even 3) additional incisions are made. A posterior port incision is made either 1 fingerbreadth below the tip of the scapula (for upper and middle bilobectomy) or 3-4 fingerbreadths below the scapula tip (for middle and lower bilobectomy). Lastly, a 4-cm utility incision is made overlying either the superior or the inferior pulmonary vein, depending on which 2 lobes are resected. Occasionally, this incision has to be lengthened depending on the size of the tumor. A tissue retractor can be placed in this incision (refer to Fig. 3 inset) to protect the skin from tumor spillage and trauma from repeated instrument exchange. For an upper bilobectomy, it is often easier to divide the vascular structures and airway via the camera port incision. If an additional incision is required, an incision can be made in the posterior axillary line in the eighth or ninth intercostal space.

Right Upper and Middle Lobectomy

For upper bilobectomy, the dissection is started at the hilum. The phrenic nerve is first swept away from the hilum and the superior pulmonary vein is identified (Fig. 4A). Mediastinal pleura overlying the superior pulmonary vein is opened either using a scissor via the utility incision or an energy device depending on the surgeon's comfort level. Typically, the right middle lobe venous drainage is via the superior pulmonary vein. The main trunk can be divided with a single vascular-load stapler or the upper lobe and middle lobe branches can be divided individually. However, one should identify and make sure the inferior pulmonary vein is spared in case the right pulmonary vein bifurcates late within the pleural space.

Pulmonary artery dissection is then conducted. Blunt dissection is started at the hilum and extended into the transverse fissure. The truncus arteriosus branches are identified. Often, 2 branches are identified and they can be seen as 2 separate branches off the main pulmonary artery or they can bifurcate from a common trunk. After safe division of these arterial branches with vascular-load staplers (Fig. 4B), the posterior ascending artery is defined along the fissure and divided. However, oftentimes the right upper lobe bronchus obscures the posterior descending artery. In this case, the bronchus can be divided first while maintaining caution to not injure or avulse the posterior descending artery as it is a small vessel. The lung is pulled anteriorly and posterior dissection of the airway is performed inferior to the azygos vein. The right upper lobe takeoff is dissected out and any peribronchial or lymphatic tissue is swept up with the specimen, thus allowing adequate apposition of the bronchial cartilaginous wall and membranous portion of the airway on firing of the tissue-load stapler. Once the bronchus is circumferentially dissected, it can be divided either from an anterior exposure (Fig. 4C) or via a posterior approach while being cautious of the posterior descending artery. Lastly, the posterior descending artery is divided using an energy device or surgical clips. Next, the middle lobe dissection is performed. Once again, dissection starts at the hilum with simultaneous removal of level 10R and 11R nodes. Mediastinal pleura is opened along the oblique fissure, which exposes the superior edge of the bronchus intermedius. The right middle lobe bronchus is carefully dissected and isolated. After making sure that the right lower lobe takeoff is not compromised with a clamp test, the right middle lobe bronchus is divided via the camera or optional port (Fig. 4D). The only structure that is left to transect is the right middle lobe artery. This can be found directly behind the middle lobe bronchus. Using the bronchus as a landmark, the right middle lobe artery is identified to be directly feeding the right middle lobe when lifted straight up within the pleural cavity. After carefully dissecting it, the artery can be divided using a vascular-load stapler through the camera or the optional port (Fig. 4E). Finally, the specimen is removed after completely dividing the oblique fissure (Fig. 4F) using an EndoCatch bag via the utility incision to prevent any tumor spillage and contamination.

Right Middle And Lower Lobectomy

For a lower bilobectomy, the dissection starts with division of the inferior pulmonary ligament. The level 9 lymph node is retrieved and the mediastinal pleural dissection is performed anteriorly and superiorly along the hilum. The phrenic nerve is carefully swept away medially. The superior and inferior pulmonary veins are identified and the right middle lobe venous drainage is determined. Venous drainage from the right upper lobe is spared and the inferior pulmonary vein and middle vein are divided together as a common trunk or separately via the camera port (Fig. 5A). The bronchus intermedius is the next structure encountered after division of the inferior pulmonary vein. This can be

divided from an anterior or posterior approach (Fig. 5B). The lymphatic tissue is swept up with the surgical specimen and the bronchus is divided using a tissue stapler. The dissection is performed very carefully so as not to injure the pulmonary artery in the fissure which is directly behind the bronchus. Lifting the middle lobe or the lower lobe within the pleural space via the utility incision helps to expose the plane between the bronchus intermedius and the pulmonary artery. The arterial branches to the right middle lobe and lower lobe are dissected next and divided at the level of the bronchus intermedius. The middle lobe arteries, superior segmental artery, and basal trunk are all divided together or separately using a vascular-load stapler following division of the bronchus intermedius (Fig. 5C). Finally, the horizontal fissure is divided using serial firing of tissue-load staplers (Fig. 5D).

Lymph Nodes, Checking of the Bronchial Stump(s), and Management of Residual Space

After bilobectomy is completed, central lymph node dissection (4R and 7 for upper bilobectomy and 7, 8, and 9 for lower bilobectomy) is performed. The bronchial stumps are tested for airleak by submerging them in saline and ventilating the right lung with positive pressure. The bronchial stump can be covered with autologous tissue such as intercostal muscle, omentum, pericardial fat pad, or pleura, but this is surgeon dependent and indeed encouraged if there is a likely chance of giving adjuvant therapy. In case of an upper bilobectomy, the inferior pulmonary ligament is divided to allow the lower lobe to expand and fill the pleural space completely at the end of the case. Pleural tenting for upper bilobectomy and creation of pneumoperitoneum for lower bilobectomy have been described in the literature; however, most surgeons typically accept the residual space and simply place 2 chest tubes and leave them on suction for a longer period of time to allow apposition of the visceral and parietal pleura and obliterate the space. Most surgeons do not perform a pleurodesis or place any muscle flaps during the initial surgery. Incisions are closed after ensuring adequate hemostasis and proper lung inflation on institution of ventilation. Almost always, the hemidiaphragm comes up on postoperative imaging after either bilobectomy. Completion bronchoscopy is performed to check the bronchial stumps and clear any secretions that may have accumulated in either lung.

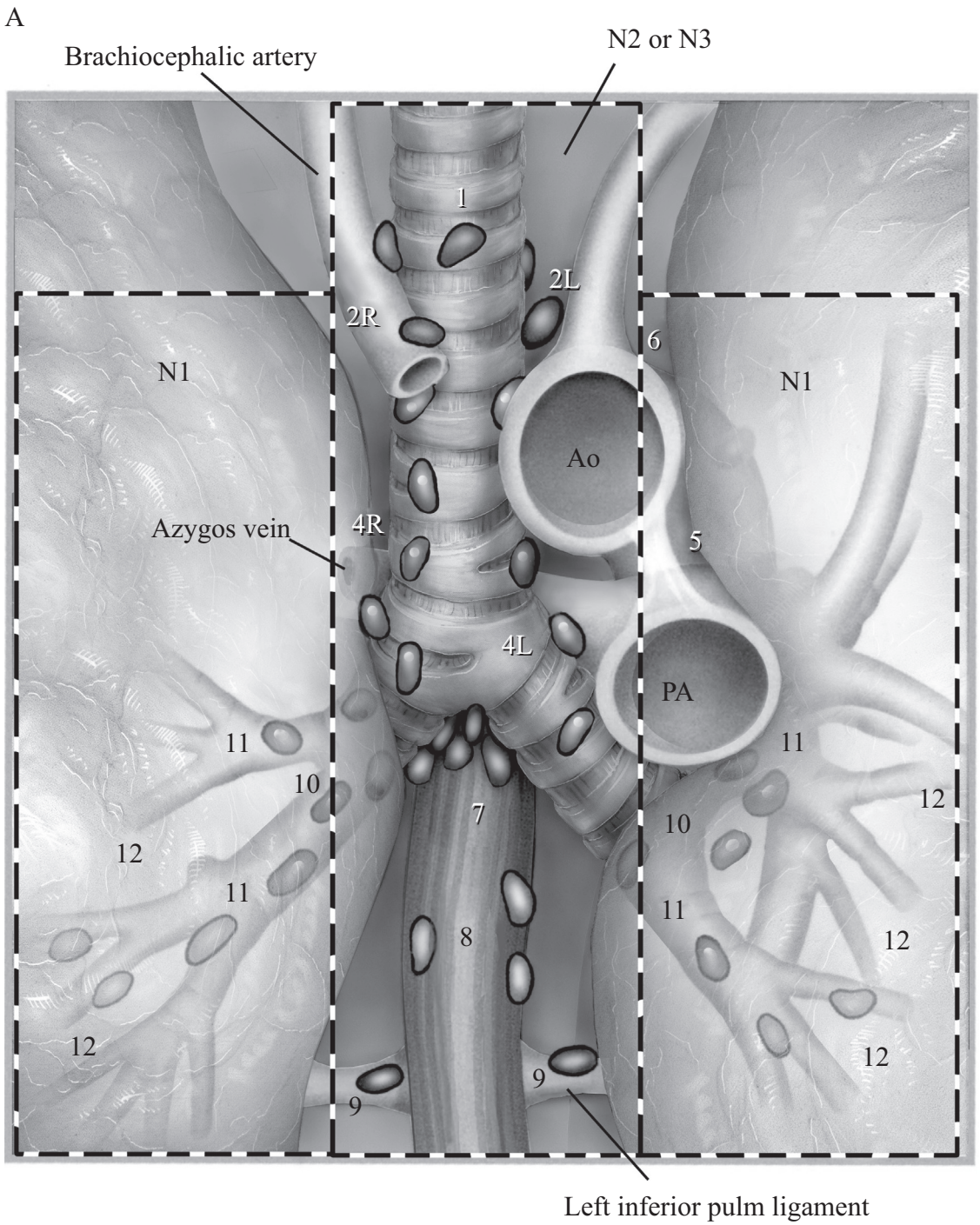

Figure 1 (A) Once a suspicious lung nodule is identified, a biopsy is typically obtained by either computed tomography–guided or navigational bronchoscopy and the patient is staged to determine N1-, N2-, or N3-category disease.

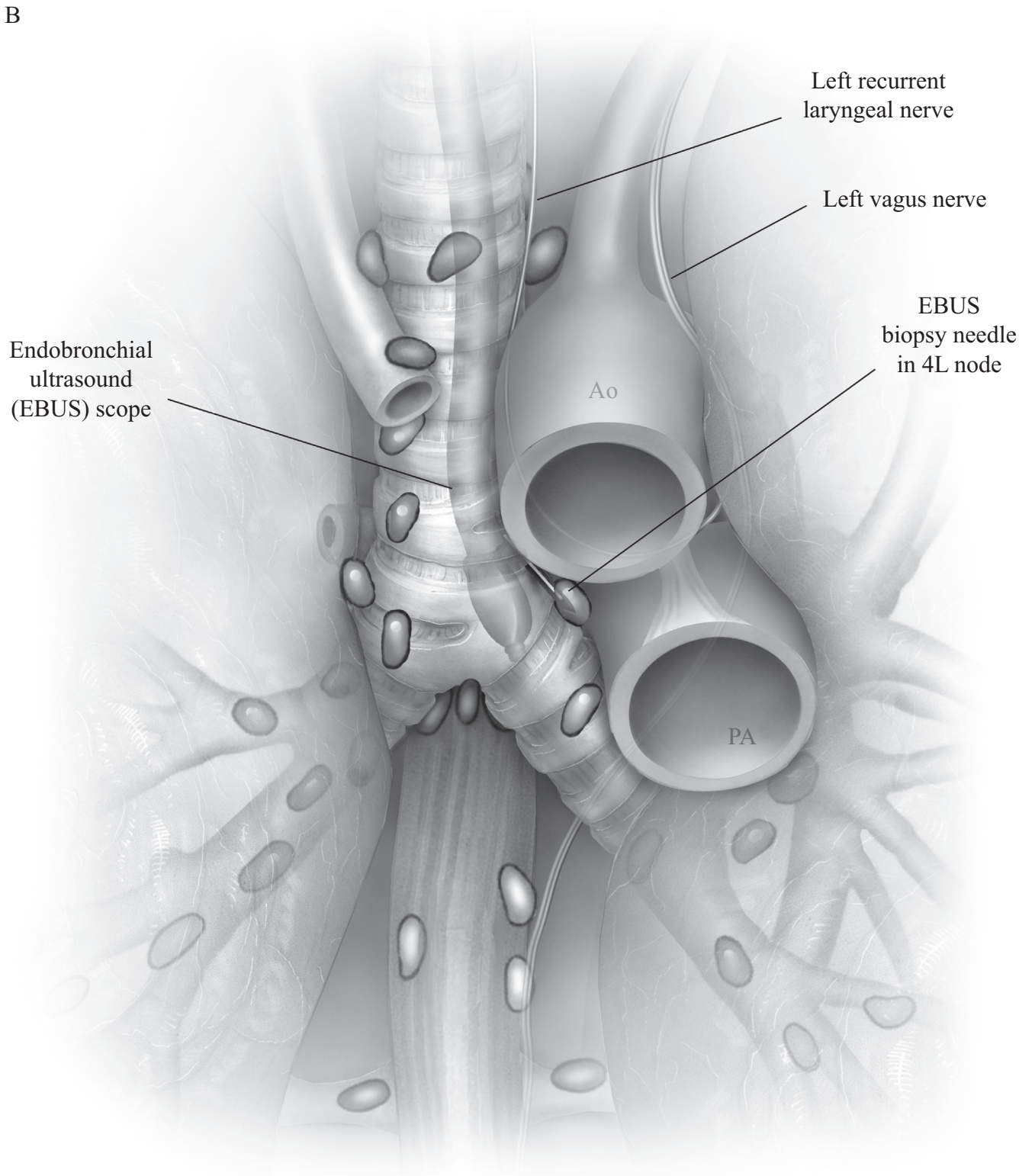

Figure 1 (*Continued*) (B and C) Staging includes a positron emission tomography scan and mediastinal staging. Mediastinum can be staged via endobronchial ultrasound (B).

C Inspection of mediastinal nodes

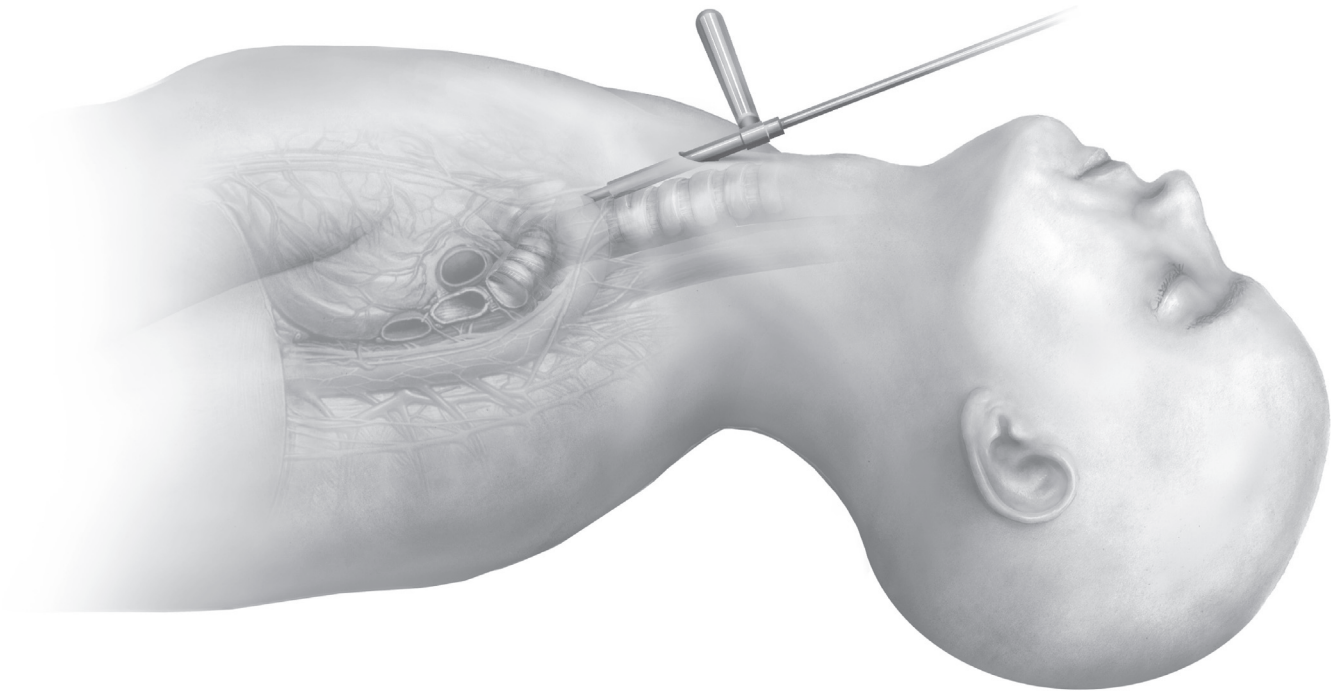

Figure 1 (*Continued*) which uses ultrasound to visualize suspicious paratracheal lymph nodes, or via cervical mediastinoscopy (C).

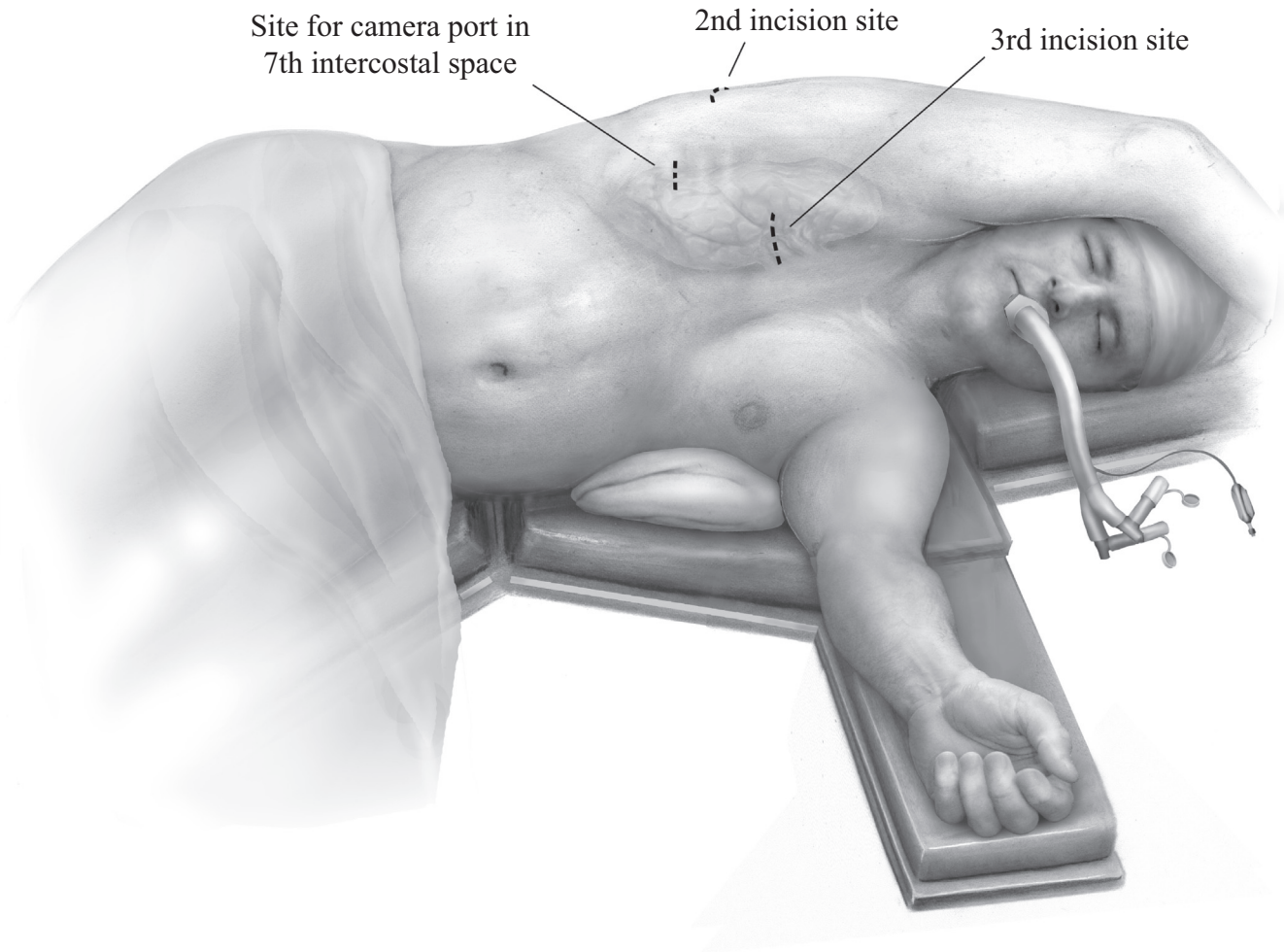

Figure 2 Thoracoscopic positioning. For a bilobectomy, a double-lumen endotracheal tube is placed and the patient is positioned in left lateral decubitus. An axillary roll is placed well below the axilla to avoid any brachial plexus injury. The operating table is flexed and either a bean bag or pillows are used to secure the patient along with padding all the pressure points.

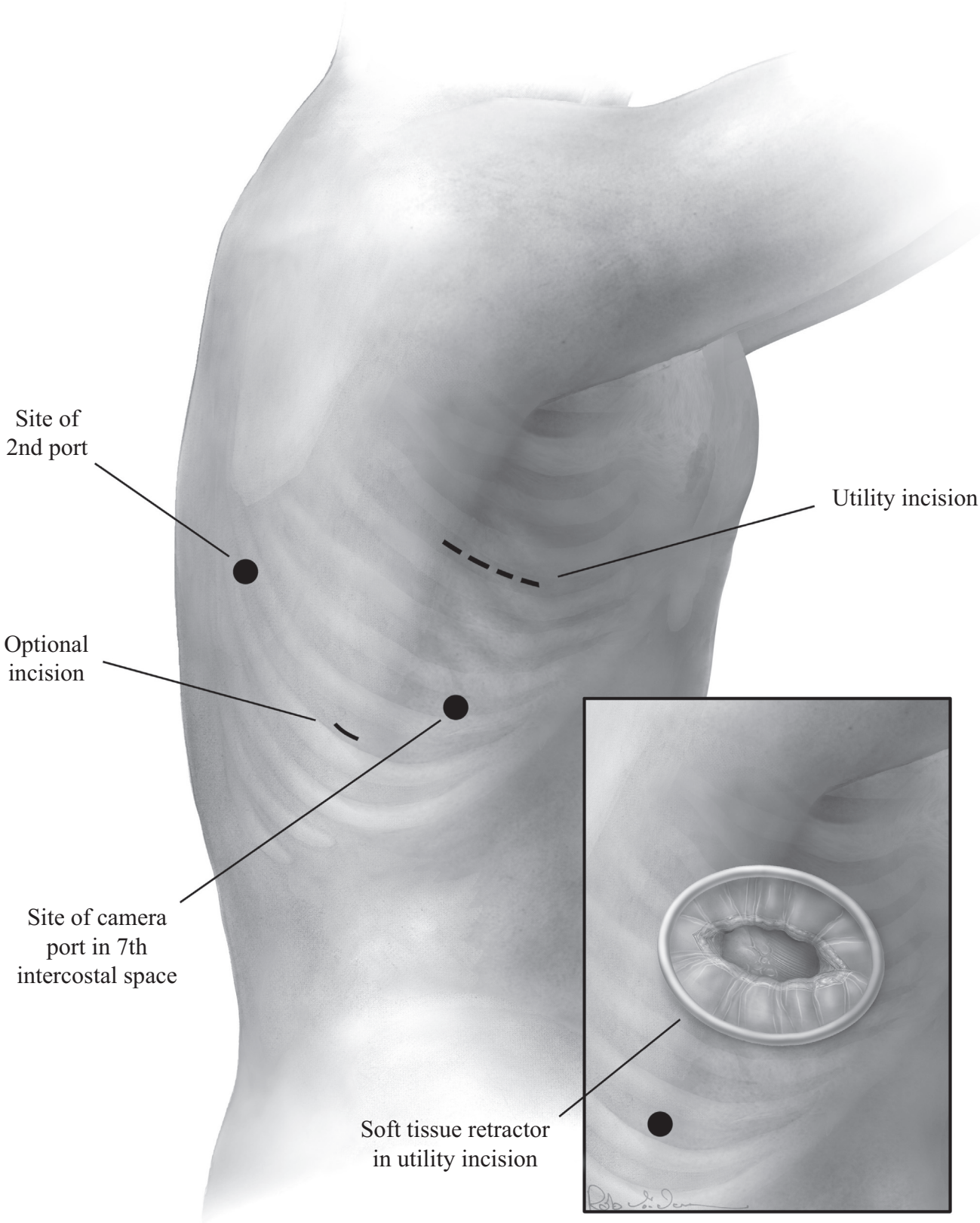

Figure 3 A standard 3-incision surgical approach is used to successfully perform a video-assisted thoracoscopic bilobectomy, either the upper and middle lobes or the middle and lower lobes. The first 1.5-cm incision is made at the seventh or eighth intercostal space at the anterior axillary line. The second working port incision is made posteriorly below the scapula. Finally, a 4-cm access incision is made in the intercostal space overlying the superior or inferior pulmonary vein under direct visualization (for an upper or lower bilobectomy, respectively). A tissue retractor (see inset) may be used to protect the wound from tumor spillage and trauma from instruments. An optional fourth incision can be made in the eighth intercostal space at the posterior axillary line for an upper bilobectomy to allow division of the vascular structures and airway to the right upper lobe.

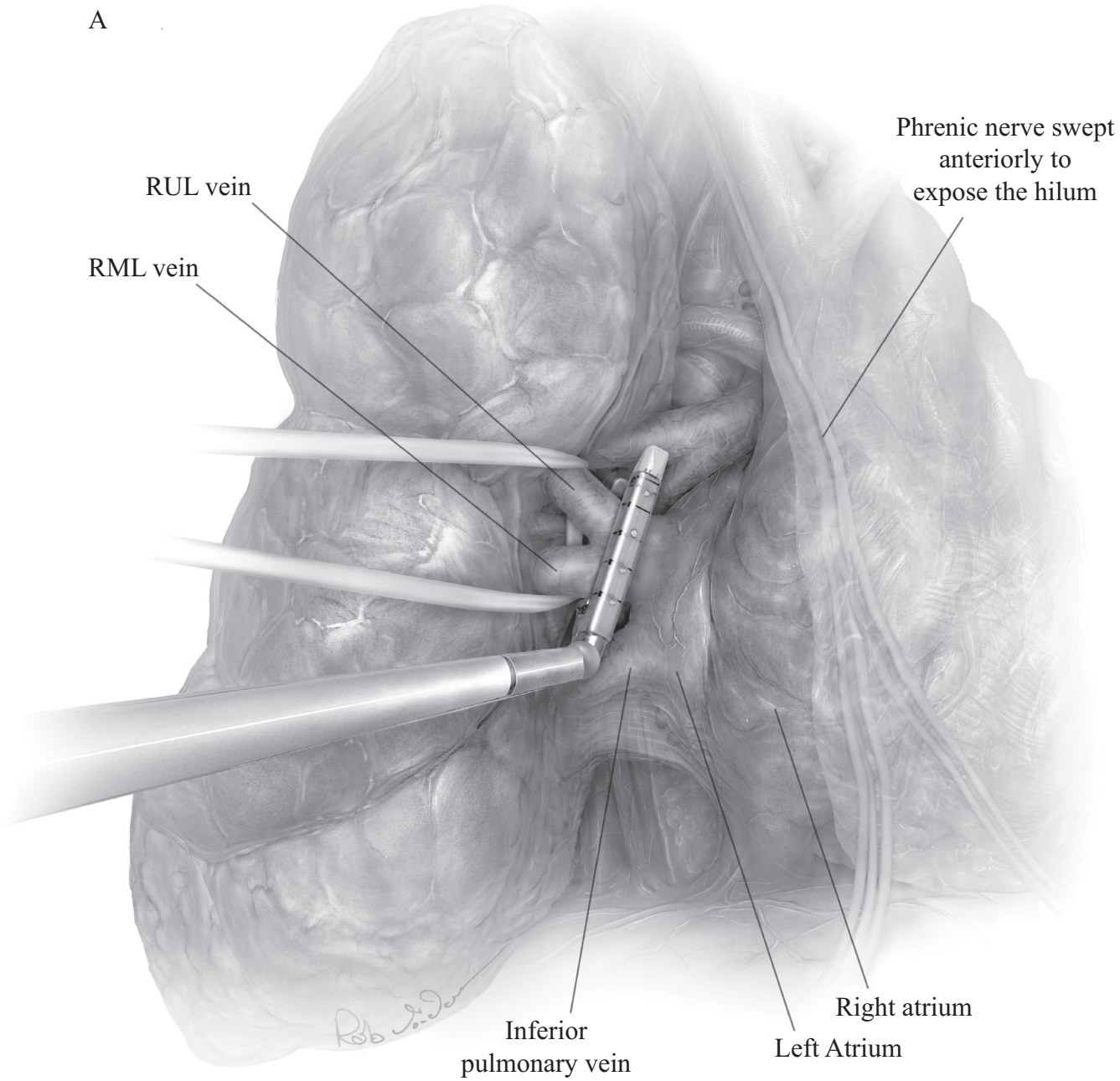

Figure 4 Upper bilobectomy. (A) Dissection starts at the hilum with division of the superior pulmonary vein anteriorly. RUL = right upper lobe; RML = right middle lobe.

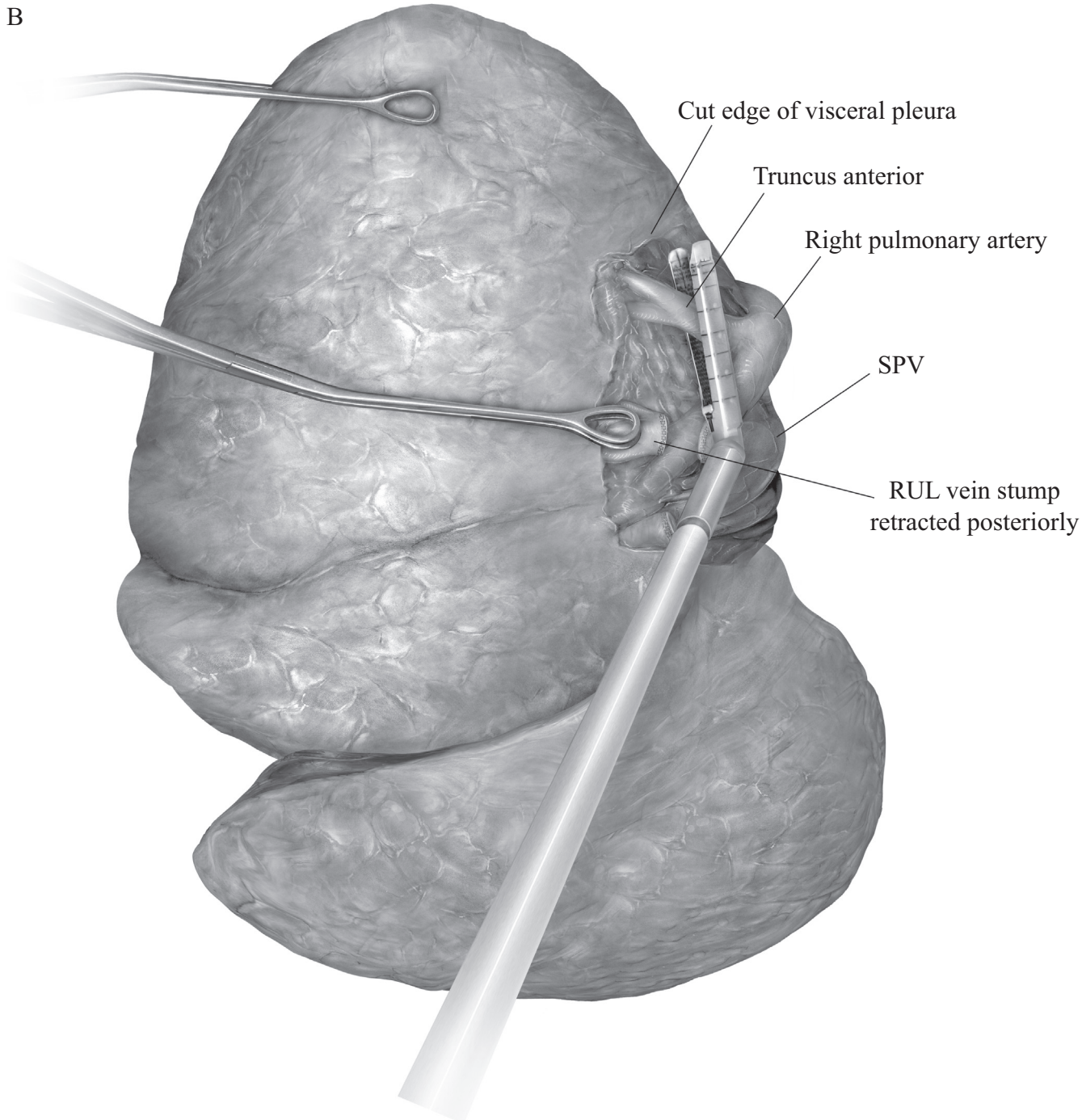

Figure 4 (*Continued*) (B) A stapler can be used to divide the right upper and middle lobe vein as a common trunk or separately. Next, the truncus anterior or the superior trunk of the pulmonary artery to the right upper lobe and posterior recurrent artery are divided. SPV = superior pulmonary vein; RUL = right upper lobe.

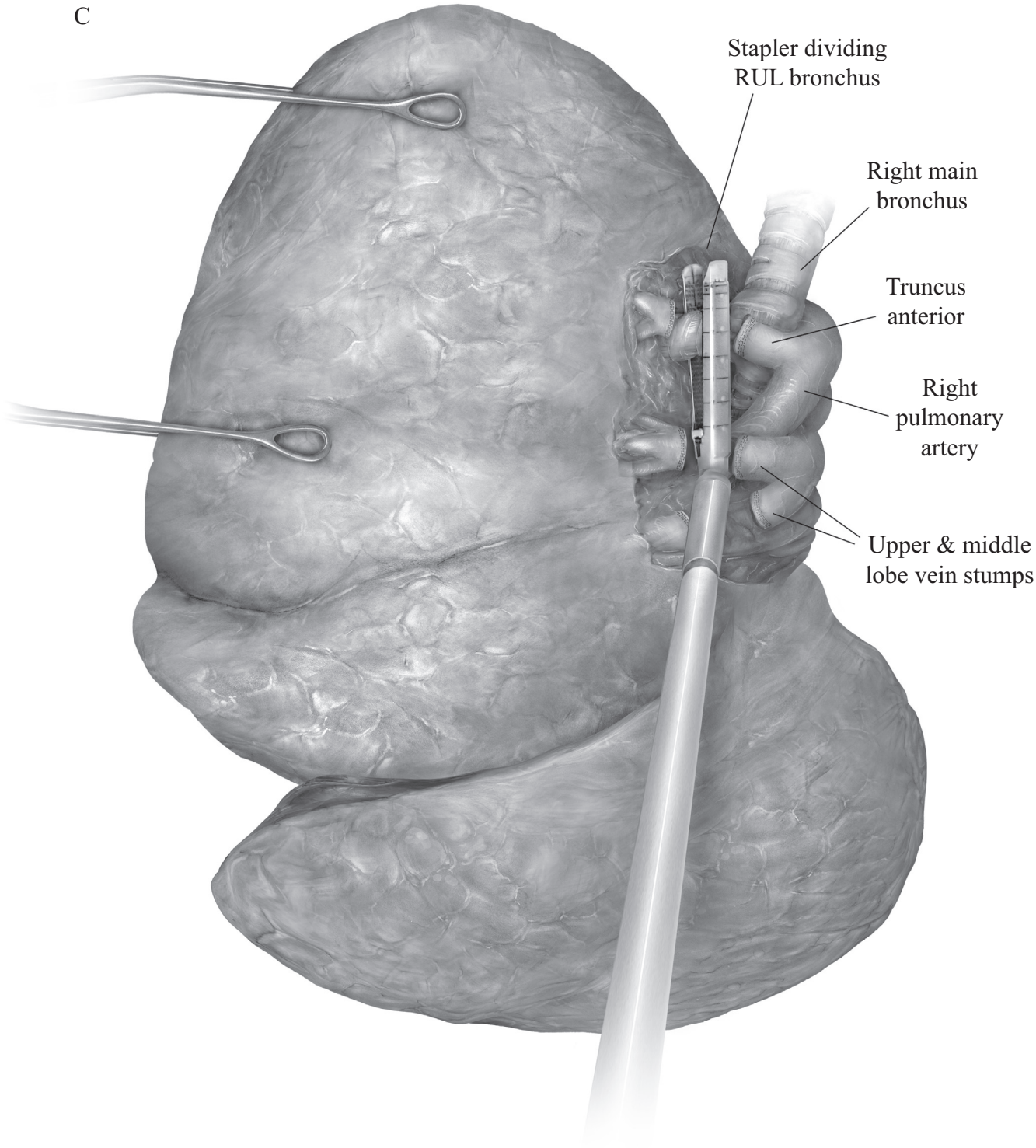

Figure 4 (*Continued*) (C) Following division of upper lobe vasculature, the right upper lobe bronchus is divided. Dissection can be performed either anteriorly (C) or posteriorly. RUL = right upper lobe.

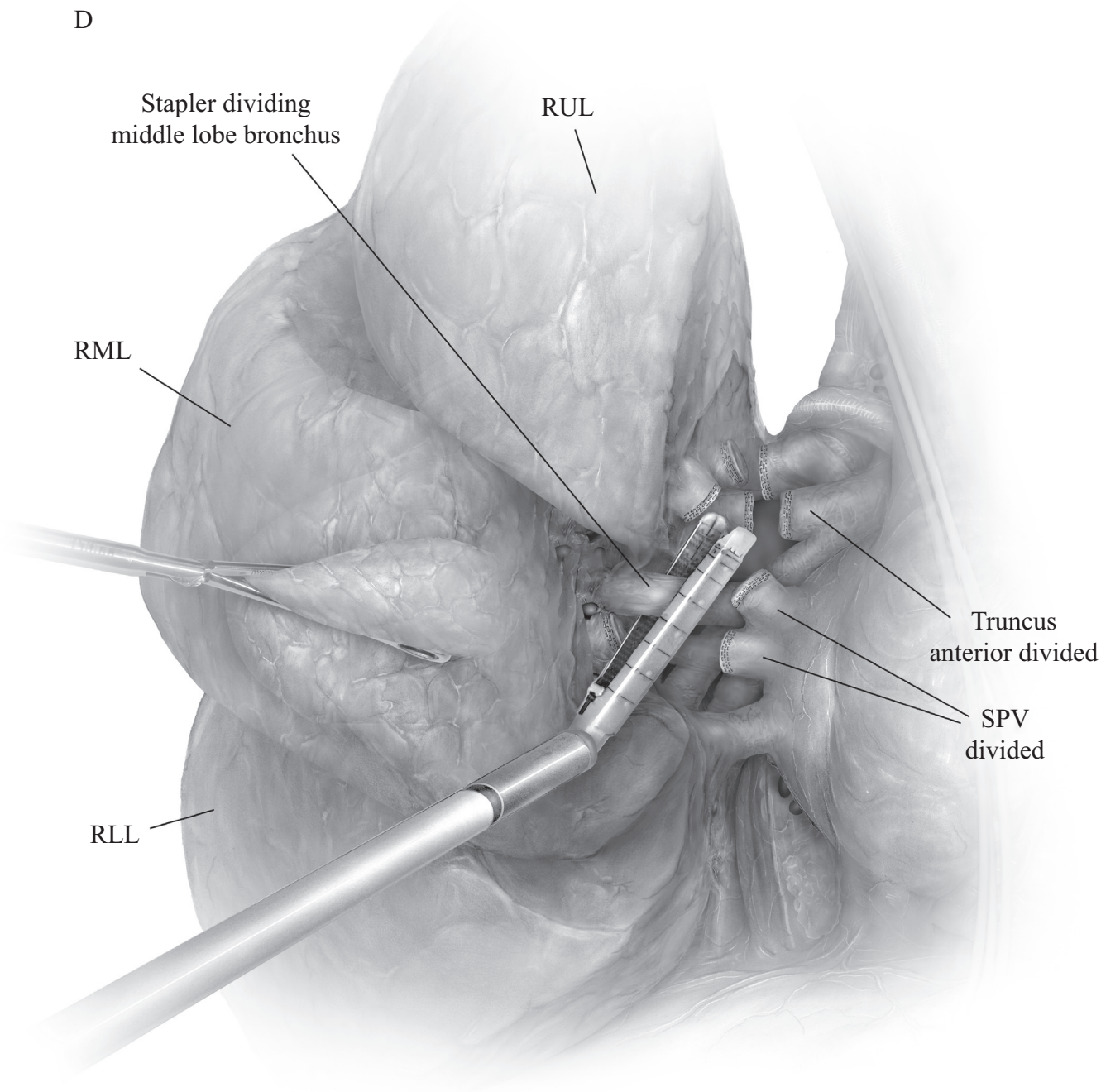

Figure 4 (*Continued*) (D-F) After isolating and division of the right upper lobe bronchus, the middle lobe bronchus is divided anteriorly (D—RUL = right upper lobe; RML = right middle lobe; SPV = superior pulmonary vein; RLL = right lower lobe) followed by the middle lobe artery behind the bronchus.

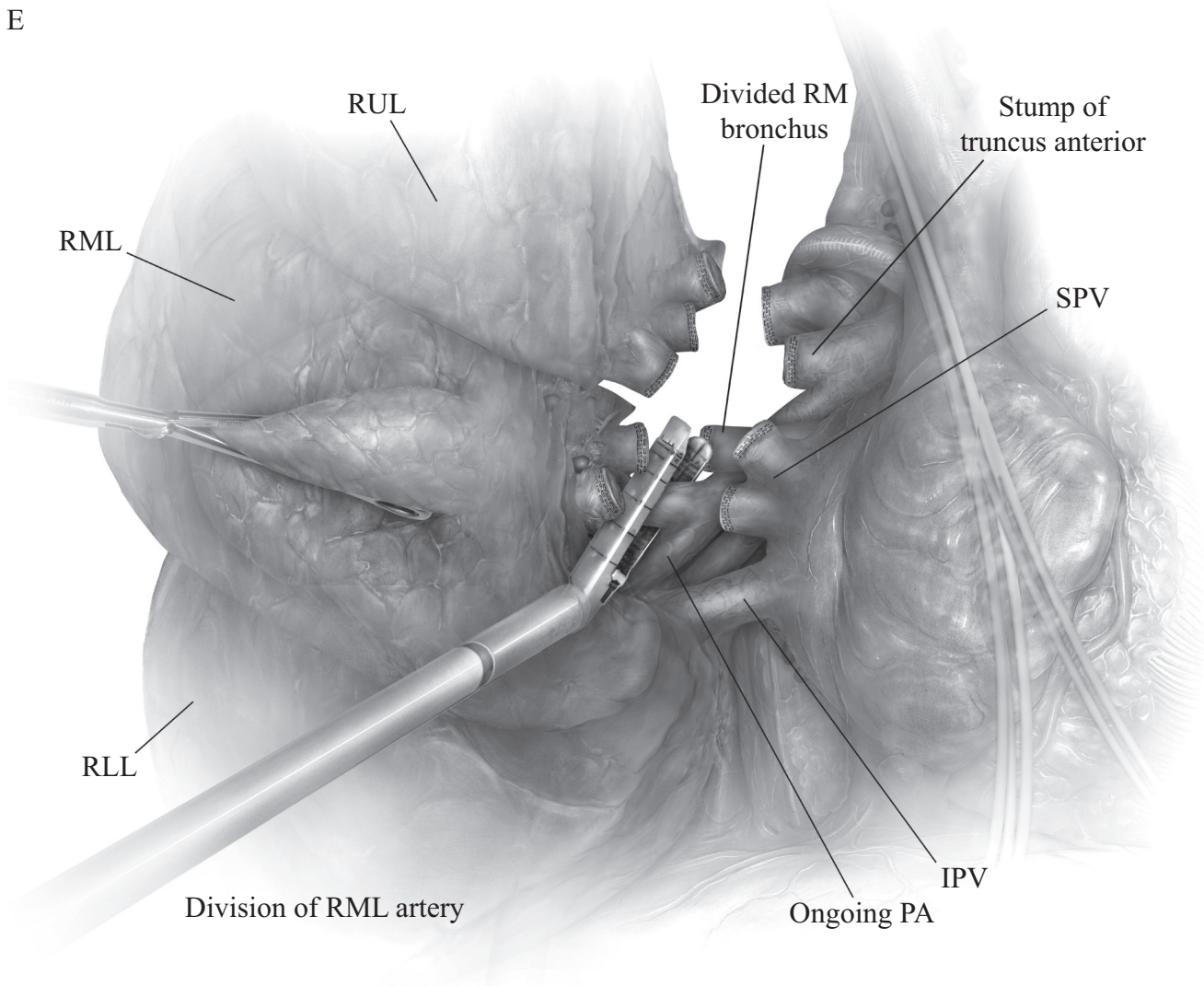

Figure 4 (*Continued*) (E) RUL = right upper lobe; RML = right middle lobe; SPV = superior pulmonary vein; PA = pulmonary artery; IPV = inferior pulmonary vein; RLL = right lower lobe). Preservation of blood flow to the superior segment is ensured, and before division of the middle lobe bronchus, it is made sure that the lower lobe airway is not compromised. Finally, the oblique fissure is divided, separating the surgical specimen from the right lower lobe.

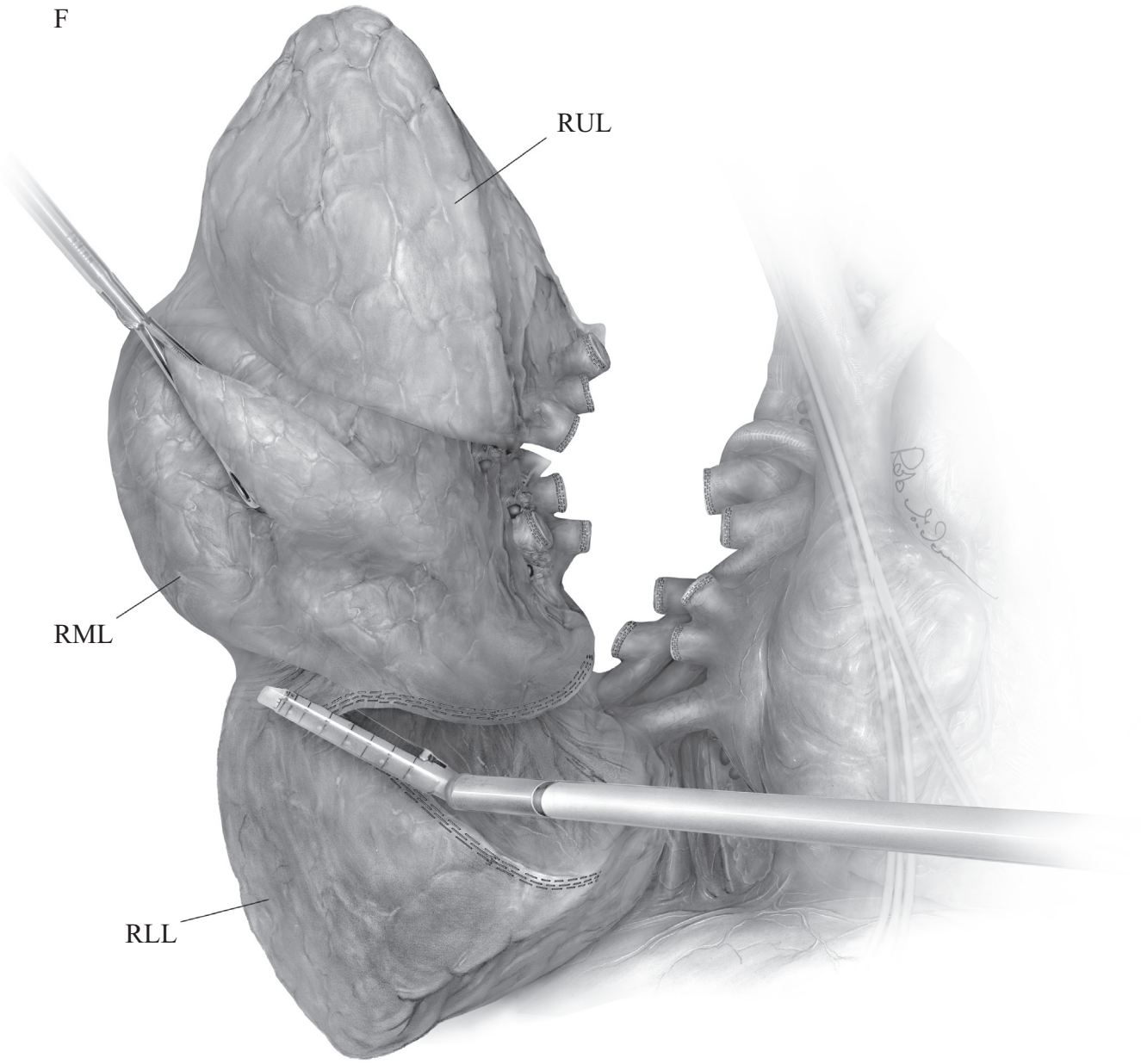

Figure 4 (*Continued*) (F) RUL = right upper lobe; RML = right middle lobe; RLL = right lower lobe).

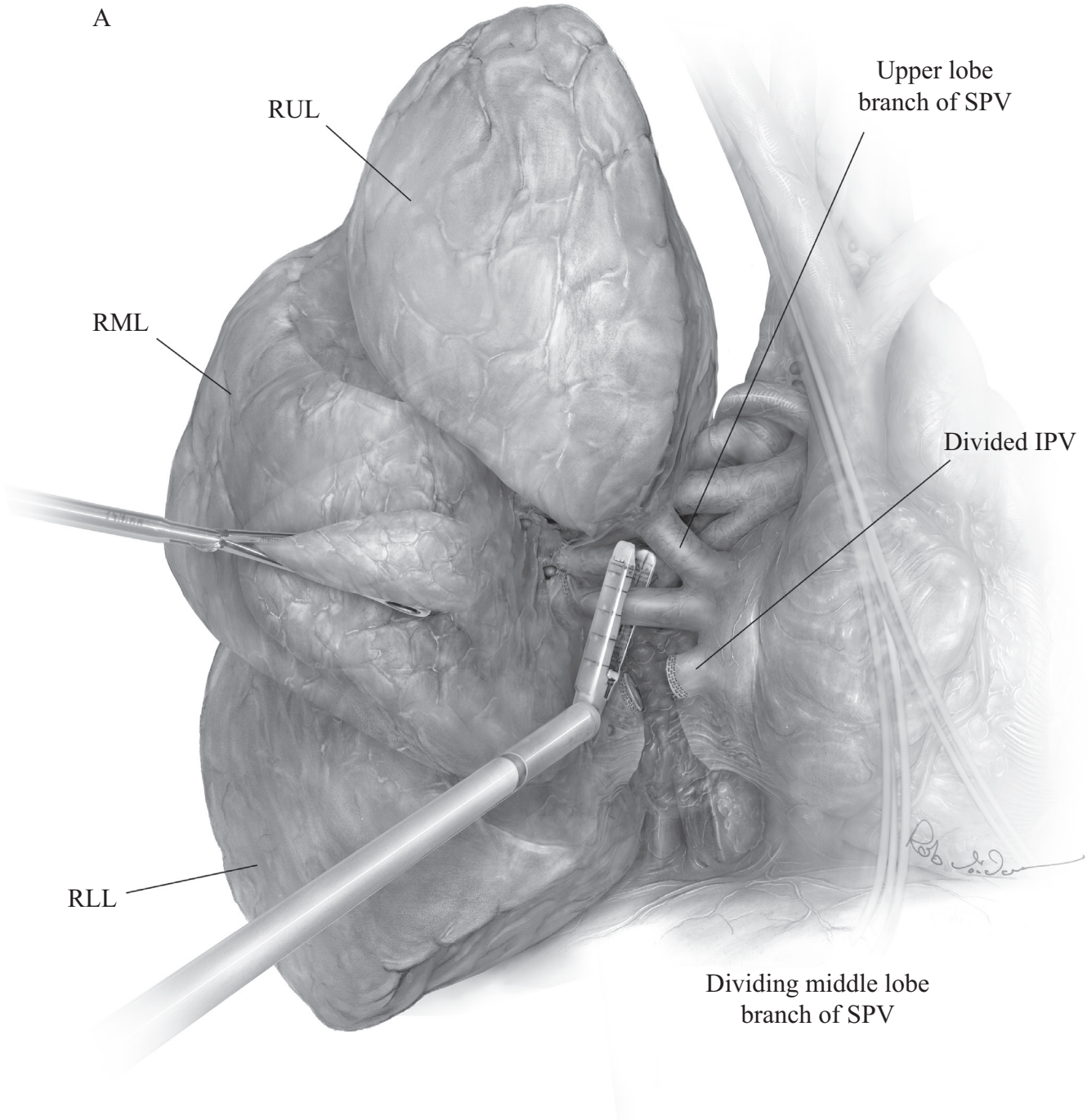

Figure 5 Lower bilobectomy. (A) Dissection starts at the inferior pulmonary ligament. Any level 9 lymph nodes are removed as the ligament is divided (shown in the figure), and the inferior pulmonary vein is divided. After its division, the mediastinal pleura is opened anteriorly and the middle lobe vein is divided. RUL = right upper lobe; RML = right middle lobe; SPV = superior pulmonary vein; IPV = inferior pulmonary vein; RLL = right lower lobe.

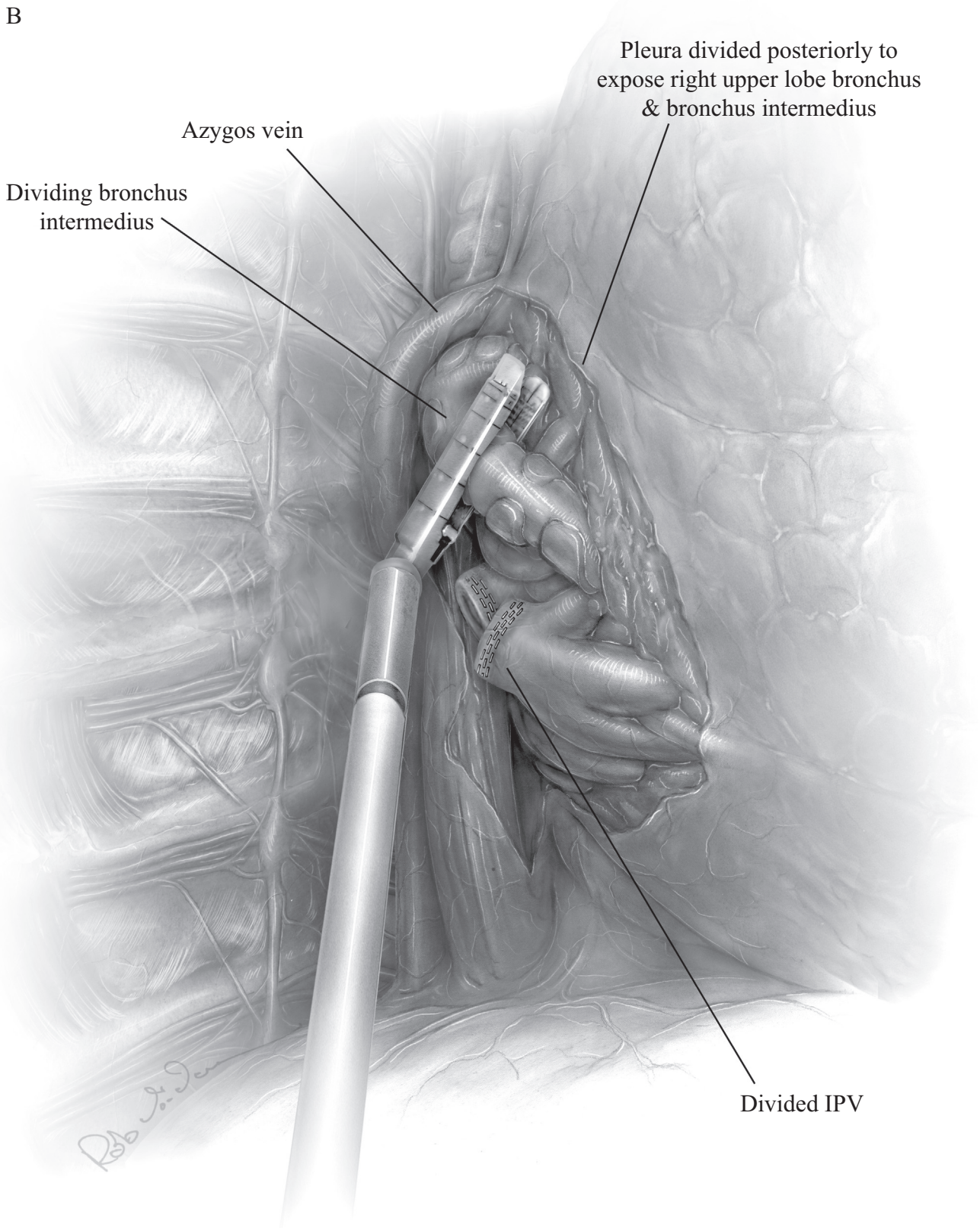

Figure 5 (*Continued*) (B and C) Next, the airway is divided posteriorly. The lung is pulled anteriorly and dissection is carried out between the upper lobe bronchus and bronchus intermedius. This dissection can be facilitated by lifting the lower lobe straight up, which allows a plane to be developed between the bronchus intermedius and the pulmonary artery. Ensuring that the right upper lobe bronchus is not compromised, the bronchus intermedius is divided (B—IPV = inferior pulmonary vein). Arterial blood supply is divided next after dissecting in the fissure. This dissection can be performed from an anterior or posterior approach. Adequate dissection is performed to visualize the superior segmental artery and the middle lobe arteries, and the pulmonary artery is divided proximal to these branches just distal to the posterior recurrent artery (C—RUL = right upper lobe; RML = right middle lobe; RLL = right lower lobe).

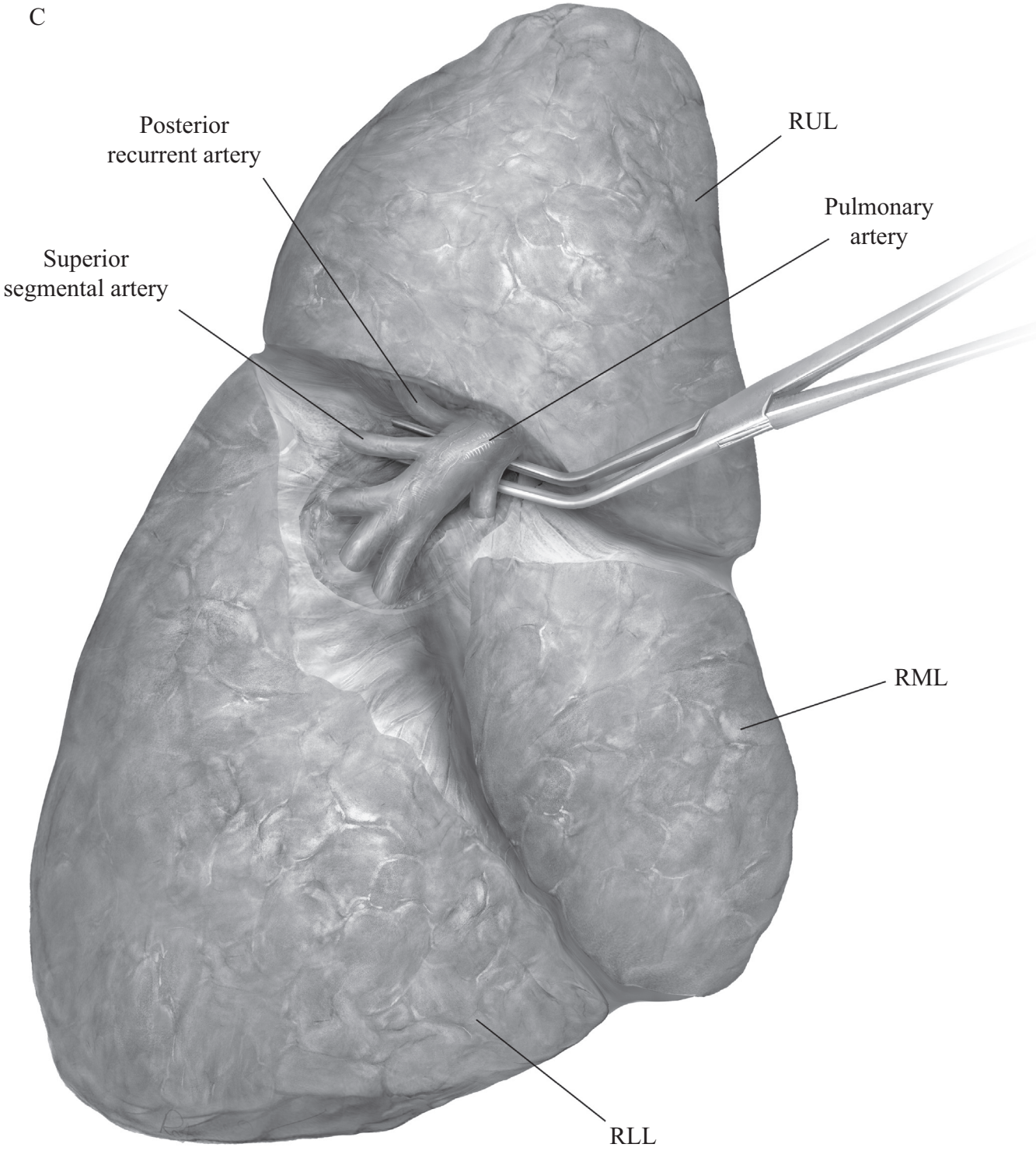

Figure 5 (*Continued*)

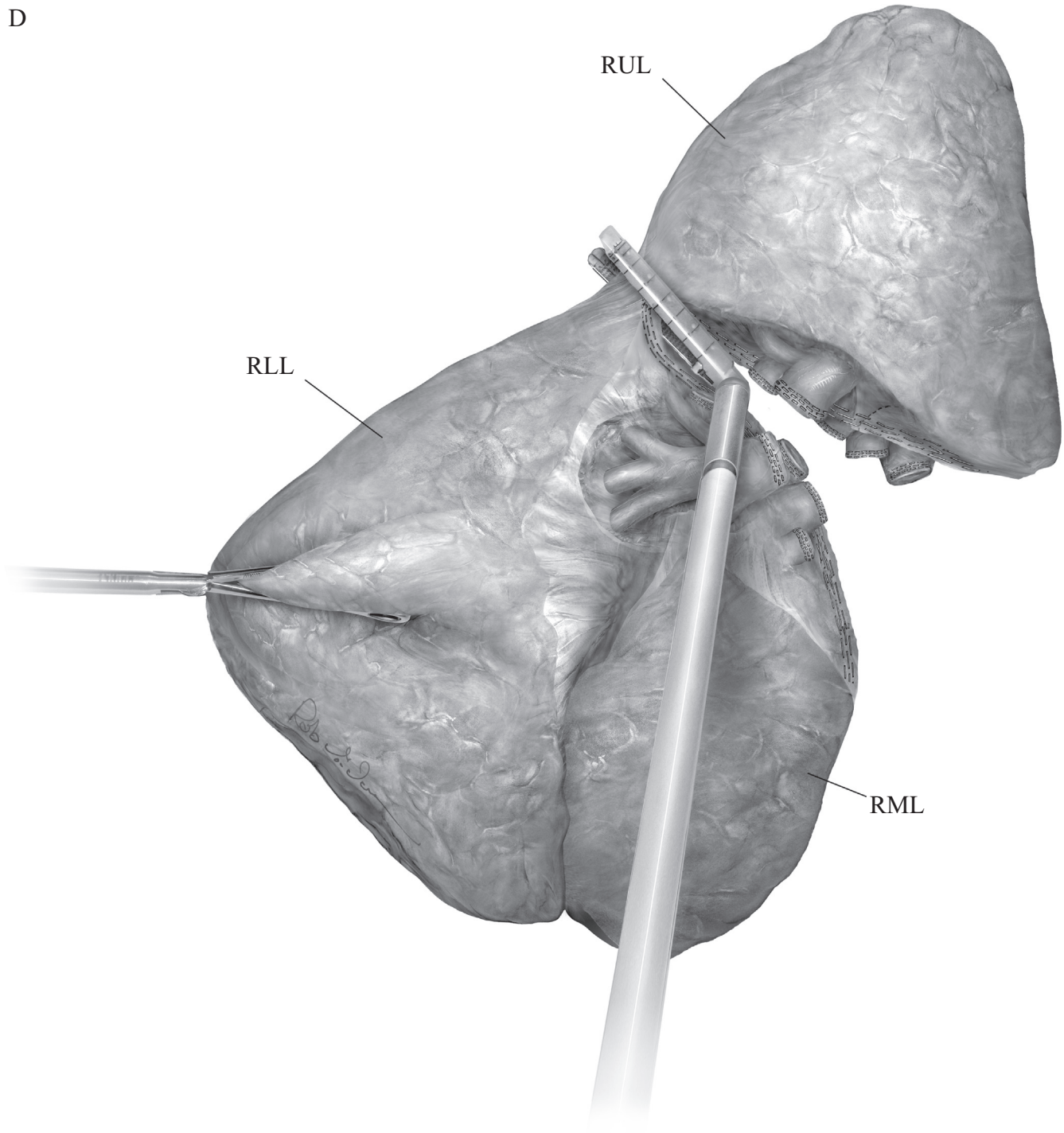

Figure 5 (*Continued*) (D) Finally, the horizontal fissure is divided (D) and the specimen removed. RUL = right upper lobe; RLL = right lower lobe; RML = right middle lobe.

Summary

The goal of this article is to provide practicing surgeons structured steps to performing bilobectomy via a video-assisted thoracoscopic approach. Bilobectomy is indicated for certain tumor morphology and tumor locations with goal of R0 resection. Thoracoscopic bilobectomy can be successfully achieved with systematic dissection and careful division of pulmonary veins, arteries, and the airway. Lymph node dissection, testing, and coverage of the bronchial stump and appropriate management of the pleural space completes the resection. The 5-year survival rates are acceptable for both upper and lower bilobectomies.

Acknowledgments

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